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Case Report

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Echocardiography in the diagnosis of heart failure with preserved ejection fraction: A case report illustrating the challenges, limitations and promise of new methods

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Abstract

Accurate diagnosis of patients presenting with dyspnea when Heart Failure with Preserved Ejection Fraction (HFPEF) is suspected can be challenging. The proper diagnosis has significant implications for patient management. Misdiagnosis can lead to inappropriate treatment strategies and poor outcomes. Echocardiography serves as the imaging modality of choice in the evaluation of patients with suspected HFPEF and echocardiographic parameters are incorporated in both of the commonly used clinical algorithms. Despite the utilization of multiple conventional echocardiographic parameters, the diagnosis of HFPEF can remain challenging in some patients and new echocardiographic methods might improve diagnostic accuracy.

Introduction/background

This case illustrates how emerging technologies like left atrial strain imaging and artificial intelligence may be used when conventional echocardiographic methods and clinical algorithms yield equivocal results. However, as demonstrated in this case, even these advanced tools sometimes yield contradictory results, highlighting the need for continuing evolution of HFPEF diagnostic strategies.

Case report

A 67-year-old female presented to cardiology clinic with unexplained exertional dyspnea and poorly controlled hypertension. Her past medical history includes hypertension, GERD, osteoarthritis, opioid use disorder, and tobacco use. She reported being able to ascend one flight of stairs, but experienced increased breathlessness when carrying heavy objects or during moderate physical activity. Her medications included carvedilol 25 bid, losartan-hydrochlorothiazide 50 mg - 12.5 mg daily, pantoprazole 40 mg bid and methadone 92 mg daily. On physical exam she had a heart rate of 61, and blood pressure of 174/72, with no other significant findings on physical exam. Laboratory studies included normal electrolytes and renal function, and a B-Type Natriuretic Peptide (BNP) of 109. The consulting physician ordered an echocardiogram, which showed Left Ventricular (LV) ejection fraction of 73%, normal regional wall motion, normal wall thickness, normal LV mass, and Left Atrial (LA) volume index of 17.6 ml/m^2 which was also in the normal range. Doppler and tissue Doppler assessment yielded a mitral E velocity of 85.7 cm/s, and A velocity of 100.0 cm/s, E/A ratio of 0.86, septal e', and lateral e' velocities of 5.2 cm/s and 5.0 cm/s respectively, and an average E/e' ratio of 16.9, There was mild Tricuspid Regurgitation (TR) with a peak TR velocity of 2.56 m/sec and an estimated Right Ventricular Systolic Pressure (RVSP) of 30 to 35 mmHg. The clinician consulted the 2016 American Society of Echocardiography Guidelines document for assessment of diastolic function to evaluate for the presence of diastolic dysfunction (Figure 1A) [1]. The lack of both significant Left Atrial

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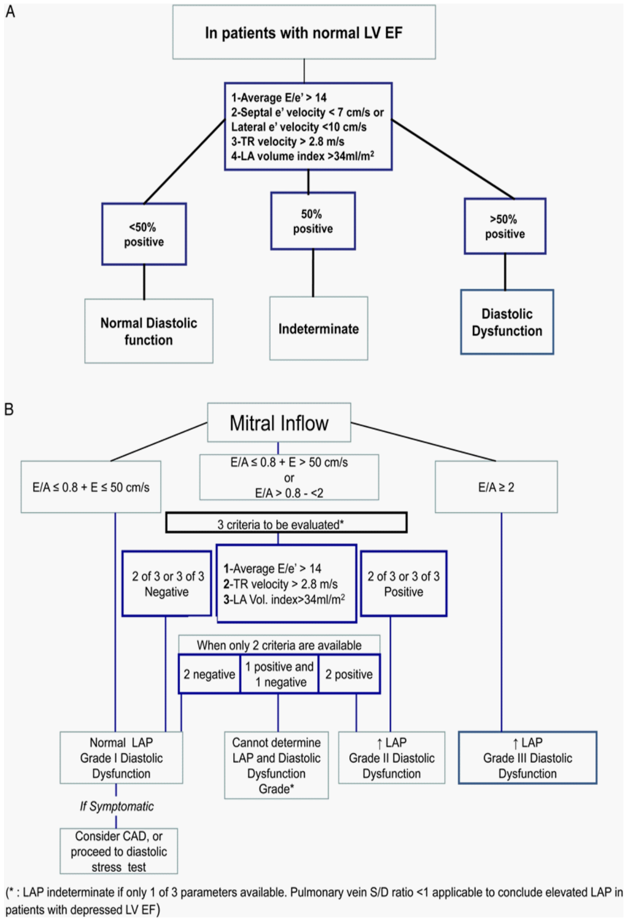

Figure 1: 2016 ASE/EACVI guideline for diastolic dysfunction.

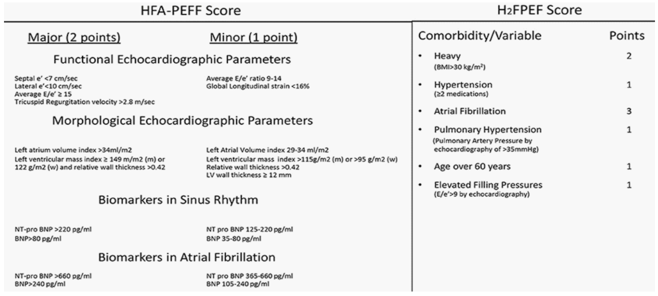

Figure 2: HFA-PEFF score and H2FPEF score.

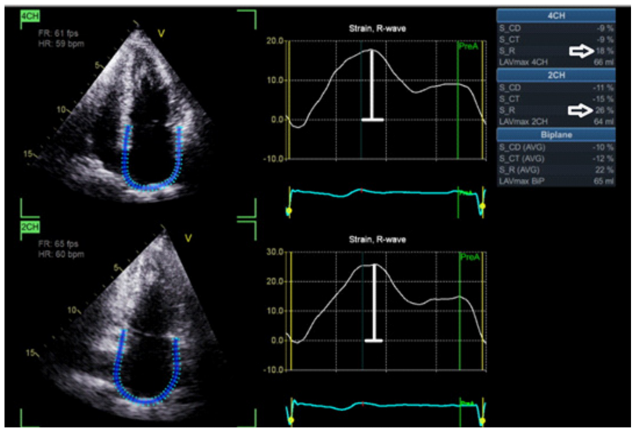

Figure 3: The line demarcates the extent of LA stretch during the reservoir phase. The 4-chamber and 2-chamber views show a strain of 18% and 26% respectively. Biplane average is 22%.

(LA) dilatation and elevation of TR jet velocity resulted in assessment of diastolic function as “indeterminate.” The clinician also utilized the guidelines for assessment of LA pressure (Figure1B) [1]. The E velocity of 85.7 cm/sec and the E/A ratio of 0.86 directed the clinician to the central branch of the decision tree. The presence of only one positive criterion for elevated LA pressure (E/e’ ratio > 14) with two negative criteria resulted in classification of the patient as having normal LA pressure.

The clinical and echocardiographic data were also applied in the two diagnostic algorithms for HFPEF, i.e., the H2FPEF and HFA-PEFF scores [2] (Figure 2). The H2FPEF score was 3 which was 50% positive corresponding to indeterminate. The HFA-PEFF score was 5 suggesting a diagnosis of HFPEF.

Despite equivocal-negative results from the diastolic function guidelines and conflicting results from the two scoring algorithms, the consultant retained a high suspicion that the patient had diastolic dysfunction, and either elevated LA pressure at rest or the potential for elevation of LA pressure with exercise as the cause of dyspnea. The physician considered that the diagnosis of HFPEF was probably appropriate in this case but also felt that additional information from the echocardiogram might help to confirm the diagnosis. Two newer echocardiographic methods were applied. Utilizing two-dimensional speckle tracking, left atrial reservoir strain was assessed. Biplane LA reservoir strain was found to be reduced at 22% (Figure 3). Finally, a commercially available novel artificial intelligence (AI) model that analyzes an apical 4-chamber view of the left ventricle was used. It was determined that the echocardiogram was not suggestive of HFPEF.

Discussion

This case illustrates the challenges of using conventional echocardiographic parameters for the diagnosis of diastolic dysfunction and elevated LA pressure, and the drawbacks of relying on current scoring algorithms for the diagnosis of HFPEF. This case also highlights both the potential utility and limitations that newer technologies may have.

The value and limitations of the 2016 ASE/EACVI diastolic dysfunction guidelines has been shown in studies with one of the main limitations of the guidelines being an unexpectedly high proportion of “indeterminate” exams. One study showed when the ASE/European Association of Cardiovascular Imaging (EACVI) algorithms were applied, diastolic function was indeterminate in 21.5% and 62.2% of preserved and reduced LVEF cases, respectively [3].

In the current case, diastolic function assessment was considered indeterminate based on both the absence of LA dilatation and significant elevation of tricuspid regurgitation velocity. However, both septal and lateral e’ velocities were substantially reduced even for a patient in their 6th decade and in the presence of hyperdynamic circulation which is known to increase e’ velocities [4]. This provides strong evidence that ventricular relaxation was reduced. The average E/e’ ratio was elevated which suggests the presence of elevated LA pressure, but the patient was assigned as no elevation of LA pressure, again based on the absence of LA dilatation and elevated RVSP. It is now well recognized that expected LA remodeling may not occur in a sizable proportion of patients with chronic hypertension [5].

A well-recognized limitation of algorithms like the H2FPEF and HFA-PEFF scores are the modest sensitivity and specificity, and the proportion of patients who have indeterminate results. One study showed HFA-PEFF scores yielded indeterminate results in 57% of patients, and H2FPEF scores yielded indeterminate results in 60% [6].

Assessment of LA reservoir strain has the potential to add value to currently used schemes for evaluation of diastolic function and LA pressure. Unlike conventional left atrial measurements that primarily evaluate dimensional aspects, left atrial strain assessment offers information about functional dynamics [7]. LA reservoir strain assesses expansion of the left atrium during ventricular systole and is primarily influenced by LV filling pressure and LV longitudinal systolic function [8]. LA reservoir strain declines as LA pressure increases. Left atrial reservoir strain has demonstrated greater accuracy in distinguishing HFPEF from noncardiac dyspnea when compared to other echocardiographic indices. One study determined the addition of LA reservoir strain information improved the diagnostic value of the HFA-PEFF score (area under the curve {AUC} increased from 0.71 to 0.80, P =.01) [9]. LA reservoir strain measurement has been shown to progressively decline with severity of diastolic dysfunction (DD) allowing for accurate staging of diastolic dysfunction. In this case the LA reservoir strain value of 22% would be considered to correspond to Stage 2 diastolic dysfunction [10].

Artificial intelligence is the latest advancement that has been shown to improve the accuracy of diagnosis of HFPEF. A new AI model analyzing data from an apical 4-chamber view of the left ventricle demonstrated AUCs of 0.97, and 0.95 in training and validation populations, respectively for the diagnosis of HFPEF. The sensitivity and specificity were 88.7% and 85.4%, respectively, in the validation data set. The study compared the AI HFPEF model with the current clinical algorithms. The HFA-PEFF score was nondiagnostic in 54.6% of patients, while the H2FPEF score had nondiagnostic outcomes in 60.4%. In these patients, the AI model was able to correctly reclassify 73.5% of the nondiagnostic HFA-PEFF scores (54.6% of patients) and 73.6% of the nondiagnostic H2FPEF scores (60.4% of patients) [11]. In this case example, AI probably rendered a false negative result. Misclassifications by AI may stem from insufficient validation in specific patient subgroups.

This case demonstrates the importance of understanding the limitations of current diagnostic tools. Understanding why discrepancies occur and the advantages/disadvantages of newer diagnostic tools can help distinguish HFPEF from non-cardiac causes of dyspnea. Although at present, there isn't a replacement for current diagnostic algorithms, the combination of conventional echocardiographic parameters, with newer methods has the potential to improve HFPEF diagnosis.

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